

## Discovery of the Breeding Habits of *Leiopelma hochstetteri* Fitzinger

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### Abstract.

The discovery near Warkworth, in the North Auckland district, of eggs and intracapsular embryos of *Leiopelma hochstetteri* Fitzinger, 1861, is described, the development of this species proving to be of the direct type already known in *Leiopelma archeyi* Turbott, 1942. The eggs were found in holes beneath water-logged clay. The environment of adult and developmental stages of *Leiopelma hochstetteri* and *Leiopelma archeyi* is discussed briefly with reference to speciation.

Three species of New Zealand frog have been described, *Leiopelma hochstetteri* Fitzinger, 1861, *Leiopelma hamiltoni* McCulloch, 1919, and *Leiopelma archeyi* Turbott, 1942.

*Leiopelma archeyi*, the one species of which the life history is known, has been found only on the higher parts of the Coromandel Peninsula. The life history as found by Archey (1922)\* is direct: the first stages are intracapsular, and the young frogs on hatching require no surface water to continue development, but move about freely on the damp earth and vegetation.

*Leiopelma hochstetteri* occurs in a number of localities in the northern part of the North Island, having been collected at Warkworth, Huia (Waitakere Hills), Te Araroa (East Cape), and on the Coromandel Peninsula. The breeding habits of *Leiopelma hochstetteri* have remained unknown, but throughout the range of this species the adults have been found commonly half submerged in water at the sides of forested streams.

In discussing the distribution of *Leiopelma hochstetteri* and *Leiopelma archeyi* at Coromandel (Turbott, 1942), I described *Leiopelma hochstetteri* as restricted to the immediate neighbourhood of surface water, *Leiopelma archeyi* occurring as was believed only on the adjacent hill tops. Later observations by Stephenson and Thomas (1945) have shown that the two species may occur in either type of habitat, adults of *Leiopelma hochstetteri* having been found on a high ridge at some distance from surface water in company with *Leiopelma archeyi*, and *Leiopelma archeyi* a few yards from stream beds inhabited by *Leiopelma hochstetteri*. Further, on 2nd January, 1949, I discovered a specimen of *Leiopelma archeyi* partly immersed in water at the side of a stream near the top of the main Coromandel divide at an altitude of c. 1,100 feet.

It is thus evident that an overlap in range, which I had not recognised, occurs at Coromandel between the two species. In this locality the high degree of atmospheric moisture and generally damp environment, evident characteristics of the Coromandel hill tops, may be regarded as factors essential to the well-being of both species in the absence of surface water.

\* Archey's material was of this species, which he did not distinguish from *Leiopelma hochstetteri*.

I am greatly indebted to Dr. N. G. Stephenson, Auckland University College, who has now completed a full study of the development of *Leiopelma archeyi*, for certain details of life history of this species which are later to be published.† The eggs of *Leiopelma archeyi* are commonly found at some distance from surface water, frequently under cover of stones or logs in apparently dry situations, but damp enough beneath to favour the direct type of development. In some cases Dr. Stephenson has found the eggs on a wet or water-logged substratum. Under experimental conditions corresponding to this, development proceeds normally, although the young frogs after hatching may be to some degree amphibious, that is they will wriggle about in water if the situation is sufficiently wet.

In the case of *Leiopelma hochstetteri*, from the commonly observed habit of the adults of remaining closely associated with water, it has seemed justifiable to expect that the life history would include an aquatic stage, although Stephenson and Thomas (1945), from their examination of the ovaries of specimens, have discounted the alternative (Turbott, 1942) that this species might have a tadpole comparable with that of *Ascaphus*.

The following notes record the discovery at Warkworth of eggs and characteristically intracapsular embryos of *Leiopelma hochstetteri*, which is thus found to have a direct development closely similar to that already known for *Leiopelma archeyi*.

New Zealand frogs, which proved to be *Leiopelma hochstetteri*, were discovered by Mr. S. G. Gittos on his property on the slopes below the prominent peak known as the Dome (1,105 feet), near Warkworth (Turbott, 1942). The finding of the eggs is due to the continued interest of Mr. Gittos, who communicated with me in the spring of 1948, saying that he had found egg capsules containing active embryos in the wet mud of a seepage or spring. These he had kept until the young frogs hatched out, but the specimens were not retained.

The habitat of *Leiopelma hochstetteri* is here an area of second-growth or regenerating forest bordering upon farmland. The altitude (550 feet) is lower than the hill tops and ridges at Coromandel inhabited together by *Leiopelma hochstetteri* and *Leiopelma archeyi*, although there is much similarity in topography and vegetation between the two areas.

Several streams descend from a forested ridge above the property, running at lower levels through grassland as open watercourses. On the steeper slopes above, the streams pass through ravines which contain forest, although the vegetation on the surrounding hillsides consists of rough pasture. Adult frogs have been found along all forested parts of these stream-beds which have been examined, and extend downstream into the open farmland where the banks support a sheltering scrub.

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† Stephenson, N. G. Observations on the Development of the Amphicoelous Frogs *Leiopelma* and *Ascaphus*, Journ. Linn. Soc. Lond. (in the press).

The eggs were first discovered last year by Mr. Gittos a few yards below such a forested ravine, and close to the neighbouring pasture land. Three groups of egg capsules were found in the wet mud of a seepage above the stream in the shelter of a large stone. There were three adult frogs under the stone; they did not appear to have been sitting over the eggs, although this habit has been observed in the case of *Leiopelma archeyi*.

On 16th November, 1949, in company with Mr. Gittos, I examined a more extensive seepage under the forest on the banks of another stream. This is in a hollow where the outcropping sandstone swings away some twenty yards from the stream-bed, although closing in to form steep, ravine-like banks above and below this point. The seepage is derived from a considerable flow of water which emerges along a bedding plane in the sandstones. The resulting swampy area is crossed at intervals by small but clearly-marked watercourses through which water would flow after rain. Numbers of adult and half-grown frogs were found in these drainage courses sheltering beneath stones which when lifted exposed a trickle of water.

Examination of crevices and tunnels in the extremely wet clay adjacent to the watercourses revealed more adult frogs, sitting in slowly percolating water. These holes and tunnels, in some cases descending vertically into the ground, were in most cases those of large dragonfly nymphs, and their course had been followed by the frogs a foot or more underground. It was in one such tunnel in water-logged clay that two groups of eggs were found, lying on the saturated floor of the tunnel, where they would undoubtedly be resting partly in water. As in the case described by Mr. Gittos, adult frogs were observed near the eggs, but were not sitting over them.

The two groups when found consisted respectively of ten and eleven eggs attached end to end to form a bead-like string: one group contained undeveloped eggs, but in the other the embryos were at an advanced stage and could be seen actively rotating within the capsules. Their stage of development at this time was approximately that of the 24-day old embryos of *Leiopelma archeyi* described by Archey. These notes, based upon my examination of the material when found, will be continued in detail by Dr. Stephenson, who has accepted the two groups of eggs for observation.

A search was made also in drier places along the stream above and below the seepage area, but without disclosing either eggs or adults.

It is particularly interesting that the eggs were in burrows of the highly predatory nymphs of a dragonfly (*Uropetala sp.*). Similar burrows made by *Uropetala* in peaty soil are described by Tillyard (1921). The burrows were common in the wet ground of the seepage, descending at least a foot underground as a system of branching tunnels. The nymphs were present in the wet mud in a number of burrows, some of which contained adult frogs, although there were apparently no nymphs near the branch tunnel containing the two groups of eggs.

With the discovery of the breeding habits of *Leiopelma hochstetteri* a brief assessment can be made of speciation problems. It is evident from Stephenson's results referred to above that the development of

*Leiopelma archeyi* proceeds in the same manner whatever the degree of moisture exhibited by the substratum. Dr. Stephenson's experimental work on the material of *Leiopelma hochstetteri* will probably demonstrate that the same is the case in this species. It is probable that the wider distribution of *Leiopelma hochstetteri* depends upon the habit of associating closely with surface water, and that it is thus possible for this species to live along the course of forested streams although in localities where there would be no high degree of atmospheric moisture to favour terrestrial habits as on the hill tops of Coromandel. The breeding habits of *Leiopelma hochstetteri* at Huia, Te Araroa, and in wet situations on Coromandel probably resemble those discovered at Warkworth, with similar requirements in respect to substratum; while on Coromandel the eggs would probably also develop in less wet situations similar to those of *Leiopelma archeyi*.

At the same time such an environment may be occupied, as Dr. Stephenson has shown, by *Leiopelma archeyi*, so that on the basis of these observations there would appear to be no barrier limiting this species to its present range. *Leiopelma archeyi* is generally found away from surface water on Coromandel, suggesting that its range may in fact be strictly limited by environmental factors as yet imperfectly known.

The two species, which Dr. N. G. Stephenson and Dr. E. M. Stephenson have found in the course of detailed study to be markedly distinct morphologically\*, may be regarded as having diverged in geographical isolation, possibly followed by the extinction of *Leiopelma archeyi* in most parts of its range. Invasion of the range of *Leiopelma archeyi* by *Leiopelma hochstetteri* could explain the overlap in distribution occurring so far as is known only on the Coromandel Peninsula. Further speculation as to origin would require more geological evidence than is at present available, and an interesting field is evidently open for more satisfactory ecological work on the two species. It may be suggested in conclusion that further exploration would probably extend the range of *Leiopelma hochstetteri* in the northern North Island.

Of *Leiopelma hamiltoni*, which may still exist on Stephen Island (Cook Strait), little is known and the life history has not yet been described.

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\* Personal communication.

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